

*Ministry of Agriculture, Fisheries and Food*  
*Department of Agriculture and Fisheries for Scotland*  
*Department of Health for Scotland*

# MILK POWDER



HER MAJESTY'S STATIONERY OFFICE

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# Contents

<b>PART I. COMPOSITION, PROPERTIES AND STORAGE OF MILK POWDERS</b>	<b>1</b>
MANUFACTURE OF MILK POWDERS . . . . .	1
COMPOSITION OF MILK AND MILK POWDERS . . . . .	1
<i>Chemical - Bacteriological</i>	
BULK RECONSTITUTION OF MILK POWDERS . . . . .	2
NUTRITIVE VALUE OF MILK POWDERS . . . . .	3
PHYSICAL AND CHEMICAL PROPERTIES OF MILK POWDERS . . . . .	4
<i>Particle size and shape - Flow properties - Bulk density of full cream milk powder and milk powder blocks - Solubility and dispersibility in water - Storage life - Flavour of reconstituted milk</i>	
STORAGE OF MILK POWDERS . . . . .	6
<i>Protein-sugar deterioration - Fat deterioration - Protective packing - Gas-packing</i>	
SPECIAL MILK POWDERS . . . . .	9
BUTTERMILK POWDER . . . . .	10
<b>PART II. COMMERCIAL USES OF MILK POWDERS</b>	
MILK POWDERS . . . . .	12
BUTTERMILK POWDER . . . . .	12
BAKING AND FLOUR CONFECTIONERY . . . . .	12
<i>Bread - Flour confectionery - Dry cake mixes - Egg albumen substitutes</i>	
MARGARINE . . . . .	14
CHOCOLATE AND CONFECTIONERY . . . . .	14
MANUFACTURED MEAT PRODUCTS . . . . .	15
SOUPS . . . . .	15
ICE CREAM . . . . .	15
CANTEENS AND INSTITUTIONS . . . . .	16
FEEDINGSTUFFS . . . . .	17
<i>Calves - Pigs - Poultry, including turkeys</i>	
BIBLIOGRAPHY . . . . .	19



## Foreword

THE manufacture of milk powder has increased more than that of any other milk product in recent years. Already three times as much milk powder is made in the United Kingdom as before the war.

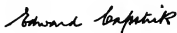
This growth has been accompanied by remarkable improvements in the bacteriological quality of the product resulting from better hygienic conditions in manufacturing creameries and greater efficiency of the plant and techniques used in drying milk.

As a result, home-produced milk powder made in accordance with the Code of Practice accepted by the Association of British Manufacturers of Milk Powder is now included, not only as an important ingredient of infant and invalid foods, but also in many of the manufactured foods which are available today.

Many potential users of milk powder may, however, have been deterred by lack of knowledge about the composition of milk powders, the difference between the spray and roller processes and the effect of incorporating milk powder in composite foods.

These are some of the points which this booklet, prepared by the Milk Powder Sub-Committee of the Milk and Milk Products Technical Advisory Committee, sets out to consider in simple and concise terms.

I am, therefore, confident that the many users (and the even greater number of potential users) of milk powder will be grateful for the work of Mr. P. K. MacKenzie and his Sub-committee in producing this publication which sets out for them, in convenient form, both theoretical and practical information on milk powder. A bibliography is provided for those who wish to make a more detailed study of the subject.



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O.B.E., M.C.,

*Chairman Milk and Milk Products  
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June, 1961



# Milk Powder

THE purpose of Part I of this booklet is to give commercial users of milk powder a knowledge of its chemical and bacterial composition and nutritive value, and the best ways of maintaining the quality of fresh powder during storage. In Part II, examples of commercial usage of milk powders in various industries are provided.

This account is by no means exhaustive, and further information can be obtained from the works included in the short bibliography at the end, to which numbered references are made in the text.

## PART I. COMPOSITION, PROPERTIES AND STORAGE OF MILK POWDERS

### MANUFACTURE OF MILK POWDERS

Two types of milk powder are generally available. *Full cream* or whole milk powder is made from milk by the removal of water: in this country it will contain not less than 26 per cent fat. *Skimmed milk* powder or separated powder is made from milk from which the cream has been removed by centrifugal separation before drying. Drying is generally by the *roller* or the *spray* process. There are a number of variants of each of these<sup>1</sup>, particularly of the spray process, and the properties of the powder depend not only on the process used, but also to some extent on the type of plant and conditions of operation.

In roller drying, the milk, which is sometimes pre-condensed, is applied as a thin film to the surface of a revolving steam-heated metal drum (or pair of drums), where the water rapidly evaporates. The resulting thin film of dry milk is continually removed from the roller by a fixed scraper knife, broken up and sieved before packing. In spray drying, the milk is first submitted to a pasteurizing type of pre-heating treatment and then evaporated under vacuum to remove part of the water. The concentrated milk is then sprayed as a cloud of fine droplets into a drying chamber, where it meets a blast of hot air which evaporates and carries away nearly all the remaining water. The dried milk, in the form of fine spherical particles, is continuously removed from the plant and is ready for packing.

### COMPOSITION OF MILK AND MILK POWDERS

#### *Chemical*

Because milk comes from an animal whose breed, age and feeding all affect the amount and quality of her output, the chemical composition of milk is not constant. However, since the composition of

the milk is standardized before drying, typical percentage values for liquid milk, and whole milk and skimmed milk powders are:

	LIQUID MILK	POWDER	
	<i>per cent</i>	<i>Whole milk per cent</i>	<i>Skimmed milk per cent</i>
Fat	3.5	27	1
Protein	3.2	26	36
Lactose	4.6	37	51
Minerals	0.8	7	8
Water	87.9	3	4

It will be seen later that the big difference in fat content of the two kinds of powder has a great effect on their properties and on the types of deterioration to which they are most subject on storage.

### *Bacteriological*

From the brief account of the manufacturing methods, it will be appreciated that before milk is converted into powder it is heated sufficiently to kill all but the most resistant bacteria. These form a relatively small proportion of the total microflora of milk and, when freshly made, milk powders should therefore have only a small bacterial count.<sup>2,3,4,5</sup> As yet, there are no bacterial standards for milk powder in this country, but the milk powder industry has an agreed code of practice<sup>6</sup> designed to keep hygienic standards high. Roller dried powder usually has a much lower count than the spray dried product, primarily because of the more severe heat treatment to which it has been subjected during manufacture and probably, in part, to the simpler equipment used.

There are considerable difficulties in manufacturing and packing a powder that is completely sterile, but milk powder can now be bought with a very low and guaranteed maximum bacterial content.

In order that bacteria may multiply, they need not only a suitable nutrient medium but also a minimum amount of moisture. The moisture content of fresh and of properly stored milk powder is below this minimum requirement and the bacterial content of the powder consequently falls during storage.

### BULK RECONSTITUTION OF MILK POWDERS

If the powder has to be reconstituted before use, the following method is recommended. The water should be heated to 50–60°C (112–140°F), preferably in a jacketed pan fitted with an electrically-operated stirrer. With the stirrer switched on, the powder is added continuously in a fine stream and the heating increased a little to maintain the temperature of the mix. The powder should be added at such a rate as to avoid the formation of any "islands" of partially wetted powder on the surface of the water. Stirring should be continued after all the powder has been added until a smooth mix is

obtained. If a concentrated mix of 25-40 per cent total solids content is required, it is essential to have a sufficiently powerful multi-blade stirrer, e.g., 15-25 gal would require a  $\frac{1}{2}$  h.p. motor, 50 gal a  $\frac{1}{2}$  h.p. motor. Whether subsequent homogenization is desirable will depend on the use to which the reconstituted mix is to be put. After straining, passage through a homogenizer or colloid mill greatly improves dispersion, particularly with powders of relatively poor solubility or when the reconstitution is carried out in cold water.

Contact with copper or brass should be avoided since traces of these metals can lead to the rapid development of objectionable flavours in reconstituted whole milk.

*After reconstitution the mix should be cooled*, preferably to a temperature of about 4-5°C (37-40°F) and certainly down to room temperature (10-17°C: 50-62°F) unless it is to be used immediately. The reason for this is the ease with which bacteria, entering the mix from the equipment, the air or the operators, can multiply if the mix is kept warm for several hours or allowed to cool slowly. Furthermore, the low initial bacterial content of the milk powder allows the growth of any contaminant bacteria, which may possibly be pathogenic, to proceed in a reconstituted mix unhindered by the competition that these bacteria would normally meet in fresh milk.

In some industries milk powder is used in the dry form and the usual mixing equipment will be adequate.

#### NUTRITIVE VALUE OF MILK POWDERS

The fat and lactose of milk powder are valuable sources of energy. In addition, the fat of whole milk powder carries useful concentrations of the fat-soluble vitamins A and D. Vitamins of the B complex and vitamin C are present in the non-fatty portion of milk powder.

Of the three major constituents, however, it is the protein of milk powder which is most important nutritionally. Not only does milk protein itself have a high biological value, but it possesses the important property of supplementing the less valuable proteins of cereals and vegetables. This means that the biological value of a mixture is higher than would be expected from the individual biological values of its component parts.

The minerals present in milk powder include calcium, phosphorus, magnesium and iron. Of these, calcium is particularly important for growing children and for expectant and nursing mothers, whose calcium requirements are exceptionally high. Whole milk powder contains about 260 mg and skimmed powder about 350 mg of calcium per ounce, much greater concentrations than are present in most other foodstuffs.

The physical and chemical properties of milk powder are important because they may govern the user's choice of a particular type of powder. As already indicated, they vary with the method of manufacture and in the following notes the properties of roller and spray dried powders have been compared.

#### *Particle size and shape*

The average size of the particles of roller dried powder depends on the degree to which the sheet of dry material is broken up in passing from the roller to, and through, the sieve. There will thus be considerable variation about the mean value which, for comparison with spray dried powder, may be taken as about 0.01 in. or 250  $\mu$  ( $1 \mu = 0.0001 \text{ cm} = 0.00004 \text{ in.}$ ).

In spray drying the size of the particles is influenced by the type of atomization used, the concentration of milk and other factors in the operation of the drier. They vary from 10–200  $\mu$  but most will be found to be in the range of 30–75  $\mu$ .

The particle of roller dried powder is a solid, flat, irregular platelet, whereas the spray dried particle is a sphere containing cavities filled with air.

#### *Flow properties*

Where powder is handled in bulk it is important that it should flow readily. In general, roller dried powder, because of its larger particle size, flows more easily than spray dried powder and skimmed powder more easily than whole milk powder. There can be considerable variations between different spray powders, apparently the result of differences in the range of particle size, a powder of more uniform particle size flowing more readily.

#### *Bulk density of full cream milk powder and milk powder blocks*

Uncompressed milk powders vary greatly in the volume they occupy per unit weight. Spray dried powders are usually denser than roller powders, because the small spheres of spray powder pack together with less inclusion of air than do the small irregular plates of roller powder. Uncompressed spray dried powders vary appreciably in bulk density according to the type of plant and degree of pre-condensation of the milk, but the usual range is from about 0.5–0.6 g/ml. Treatment of spray dried powder to give the so-called "instant" powders (see page 9) results in a lower bulk density of 0.3–0.4 g/ml. The density of uncompressed roller dried powder is generally lower than that of spray powder and varies between about 0.3 and 0.5 g/ml. The bulk density of roller powders is considerably influenced by the amount of breaking-up the dried material under-

goes from the rollers to the final container. The density of the roller dried skimmed product can be increased by milling but this is not advisable with full cream powders.

Under a pressure of several tons per square inch full cream milk powders of both types can be compressed to densities ranging up to 1.1-1.2 g/ml without appreciable loss of fat, the lighter blocks being easily crumbled in the hand, but the denser ones requiring grinding in a mill before reconstitution.

#### *Solubility and dispersibility in water?*

In fresh liquid milk only the lactose and mineral salt are in true solution. The proteins are in a colloidal state and the fat is dispersed in microscopic droplets, most of which range in size initially from 2-5 $\mu$ . The solubility of milk powders when reconstituted in water depends mainly on the degree to which the heat-sensitive proteins have been affected by the drying process. Since full cream milk powder contains about 26 per cent and skimmed powder about 36 per cent protein, the solubility of the powder would fall to 74 per cent or 64 per cent respectively, if the whole of the protein were denatured.

In practice it is found that the higher temperatures to which roller dried powders are exposed frequently cause the solubility to fall to about 80 per cent whereas spray dried powders usually remain 95-99 per cent soluble. Milk powders usually have a slightly higher solubility in warm water than in cold, and the roller dried product, in particular, reconstitutes more satisfactorily in warm water.

If milk powder is placed on the surface of unstirred water it will, in greater or less degree, spread and become wetted before solution begins. The ease with which water can make contact with the particles, known as the "wettability" of the powder, is governed by such factors as the size of the particles, the density of the powder and the presence of free fat. Wettability is more important when reconstitution is to be on a small rather than on a large scale, but powder with good wettability will generally produce a smoother mix than one of poor wettability, assuming the solubility of both to be the same. Although roller dried powders are more wettable than spray dried, they are, as already mentioned, less soluble. Skimmed milk powders are usually more wettable than whole milk powders.

#### *Storage life*

Specific factors which affect the storage life of milk powder are discussed below and here only a general indication is given of the keeping quality that can be expected for different types of powder.

Milk powders of the same type can vary appreciably in keeping properties and the useful life of a powder will depend in some degree

on the purpose for which it is required. As an approximate guide, full cream milk powder kept in a closed, moisture-proof container in a temperate climate would be expected to be usable for about 12 months if made by the roller process, or for about 6 months if made by the spray process. For skimmed milk powder the corresponding periods would be about 18-24 months for the roller dried and 12 months for the spray dried variety. The presence of air within as well as around the particles of spray dried powder and the lower temperatures to which the milk has been subjected during manufacture probably contribute to the shorter life of this type of powder.

#### *Flavour of reconstituted milk*

When fresh milk powder is reconstituted in water to about 12.5 per cent total solids (whole milk) or 9 per cent (skimmed milk) the flavour will vary according to the method of powder manufacture. Roller dried powder imparts a characteristic "cooked" flavour to the milk whereas, at its best, the flavour of reconstituted spray dried powder approaches that of fresh milk. For drinking as liquid milk spray dried powder is to be preferred. The reconstituted milk should be cooled in a refrigerator before use.

#### STORAGE OF MILK POWDERS

The best conditions for the storage of all milk powders are a cool temperature, and the absence of moisture and oxygen. The degree to which these requirements have to be met will obviously depend on the length of time it is likely to be kept, the type of powder, and the kind of container. The choice of container depends on the cost and the user's requirements (see *Protective Packing*, page 8).

#### *Protein-sugar deterioration<sup>8</sup> (the "browning reaction")*

One of the changes which can shorten the normal life of milk powders, particularly of skimmed powders, is that resulting from the reaction between the proteins and the lactose (the "browning reaction"). All milk powder is hygroscopic and must be protected from atmospheric moisture if this type of deterioration is to be prevented. Any marked increase in the moisture content above the level at which the powder leaves the factory is likely to lead to an accelerated development of objectionable "stale" or "gluey" flavours on storage. At relatively high moisture contents a progressive loss of solubility in water also takes place, the solubility in cold water of spray powders being affected rather more rapidly than their solubility in hot water. In extreme cases, when powders of high moisture content are subjected to high storage temperatures, milk can develop a brown discoloration and suffer a marked loss in the biological value of its protein.

These undesirable changes in the properties of the powder are due

to a series of chemical reactions principally between the lactose and the protein, reactions which are speeded up five or six times for a temperature rise of 10°C (18°F). Deterioration of this kind is therefore much more serious at high than at low storage temperatures: a moisture content which permits a long life under cool storage conditions or a moderate life under temperate conditions may cause rapid and extensive deterioration under tropical conditions.

The effect of increasing water content is by no means one of simple proportion; at moisture contents of 3 per cent and 5 per cent the increase in deterioration is small, but thereafter the increase is rapid. For example, in a skimmed milk powder, the effect of a moisture content of 7.5 per cent is not  $1\frac{1}{2}$  times but many times worse than a moisture content of 5 per cent. In these comparisons the fat content of the powder is irrelevant; 4 per cent moisture in a skim powder being roughly equivalent to 3 per cent in a whole milk powder.

The "caking" which is sometimes observed when milk powder is allowed to absorb moisture from the atmosphere is associated with crystallization of the lactose. The conversion of this sugar (which is present in the fresh powder as a non-crystalline solid) to the hydrated crystalline form takes place only at moisture contents above 7 per cent and is greatly accelerated by high storage temperatures. It follows that if surface caking has occurred, storage conditions or the type of container employed have been unsuitable.

#### *Fat deterioration<sup>2,3,9</sup>*

In addition to the protein and sugar changes described above, whole milk powders also deteriorate through reaction of atmospheric oxygen with fat. Reactions of this type give rise to the "tallowy" off-flavours which usually limit the life of whole milk powders stored under normal or low moisture conditions. Even with skimmed milk powder stored at a humidity low enough to inhibit protein-sugar changes, some deterioration in flavour may occur after sufficiently prolonged storage in the presence of atmospheric oxygen. This is due to oxidation of the small quantities of residual fat (usually 1-2 per cent of the powder).

The increase in the rate of development of tallowiness with rising storage temperature is not nearly as rapid as with the protein-sugar ("browning") reaction, the rate of reaction being about doubled for each rise of 10°C (18°F). Exposure to strong light, particularly sunlight, accelerates tallowiness, as does the presence of traces of heavy metals, particularly copper. Raising the temperature of pre-heating of the liquid milk above that required for normal pasteurization is a widely practised means of increasing the resistance of the powder to the development of tallowy, "off" flavour.<sup>2,3</sup> This protection, which

is probably due to the production of antioxidant or metal-deactivating substances from the protein or the protein plus sugar, is achieved at the expense of the introduction of a slightly "cooked" flavour into the product.

Synthetic chemical antioxidants, such as the higher gallates and BHT (butylated hydroxy toluene), which have been claimed to show protective properties in full cream milk powder, are not permitted additives for most dairy products in the United Kingdom and some other countries.<sup>10</sup> Preparations containing vitamin E (tocopherol) and ascorbic plus citric acids have also been found to afford some protection against tallowiness in laboratory storage tests, but do not appear to be employed in practice. Australian work<sup>11</sup> in which synthetic vitamin A, added to reinforce the nutritive value of dried skimmed milk, has been stabilized against oxidative destruction by the addition of very small quantities of tocopherol and lecithin, may, however, find practical application.

#### *Protective packing*

Packing in tins (hermetically sealed) is probably the best way of preventing access of both atmospheric moisture and oxygen to the powder, as well as providing protection against insects and rodents, but the price is higher than that of some alternative containers. At the other extreme, the multiple paper sack sometimes used is unsuitable as a container for the prolonged storage of milk powder, except perhaps where the atmospheric humidity is exceptionally low. If a plastic or other moisture-resistant liner is included in the paper sack the absorption of moisture will be substantially reduced and powder in such a container should keep for about four months under normal storage conditions in this country. Once a sack is opened the moisture content of the powder will rise. If it takes more than a week or two to use the contents of such a container, it is advisable to have available a tin, with a tightly fitting lid, capable of holding a sufficient supply for immediate needs, so that the larger container is opened as infrequently as possible. Containers should be closed securely immediately after use.

A recent development in packing is the use of bonded laminates of plastic material with metal foil, usually aluminium, which are less permeable to oxygen and water vapour than most other packing materials.<sup>9</sup>

#### *Gas-packing<sup>12</sup>*

Since tallowy "off" flavours develop only in the presence of atmospheric oxygen, milk powders can be protected from this form of deterioration by replacement of the air in the container with an inert gas, such as nitrogen or a mixture of nitrogen and carbon dioxide. This is known as "gas-packing".

Removal of all the free oxygen from a tin of milk powder is not commercially practicable and, owing to the presence of air within as well as between the particles of spray powders, removal of even most of the oxygen is a matter of some difficulty. However, reduction of the concentration of oxygen in the headspace gas from the 21 per cent present in air to 2-3 per cent will give a considerable improvement in storage life. A maximum permitted oxygen content of 2 per cent has been quoted in American specifications for the gas-packing of milk powders, particularly for military use. The consistently high standard necessary in the fabrication and closing of the tins and the difficulty of removing entrapped air from spray dried powders makes gas-packing of milk powder a somewhat expensive process for ordinary commercial use.

A further refinement of gas-packing is based on the use of a mixture of nitrogen and hydrogen for replacing the air and the inclusion of a palladium catalyst to promote the combination of the last traces of oxygen with hydrogen.<sup>13</sup> Such treatment would only be envisaged for special storage requirements, possibly under conditions of high temperature for very long periods.

Even gas-packing has not so far enabled a whole milk powder to be reconstituted after storage to a product as palatable as fresh milk. This is probably one of the reasons why full cream milk powder has been less widely used for beverage purposes than skimmed powder or the reconstituted product into which the fat has been homogenized.

#### SPECIAL MILK POWDERS

In addition to the main types of powder described above, there are the powders made by manufacturers for specific purposes. Probably the most important of these are the baby foods, in which the composition is sometimes altered from that of dried milk to make them more suitable for their intended use. The manufacturers of such products give adequate instructions for the use of their foods, and it may in general be taken that most of what has been written in this booklet about whole milk powder also applies to many of these products.

Certain products of recent development, however, require special attention. These are the so-called "instant" powders,<sup>14</sup> designed originally for domestic use and sold in some countries in small packs for prompt usage, in which spray dried milk powder has been treated so that its rate of dispersion, even in cold water, is very much faster than that of untreated powder. The procedures by which some of these powders are made are likely to favour protein-sugar interaction and therefore require very careful control if adverse effects on flavour and keeping properties are to be avoided. This type of powder

## PART II. COMMERCIAL USES OF MILK POWDERS

### *Milk powders*

As indicated in the first part of this booklet there are two types of milk powder available for general use, full cream or whole milk powder and skimmed milk powder. Full cream powder is used mainly in infant and invalid foods, but skimmed milk powder<sup>18</sup> is more widely used in industry. Whether it be in the baking industry, in the manufacture of confectionery, ice cream, cooked meat products or compound animal feedingstuffs, the presence of skimmed milk solids often results in an improved product which, in many cases, is not only more nutritious but has a better appearance, palatability and sales appeal. The composition of milk powder shows little variation and this facilitates production of a product with uniform appearance, flavour and texture. The use of milk powder also offers considerable economic advantages to food manufacturers and caterers.

In some cases it may be possible, by special arrangement, to have a skimmed milk powder "tailor made" to suit the specific requirements of the purchaser (see Part I. *Special Milk Powders*).

Of the two principal types of dried skimmed milk powder, spray dried powder is more soluble, but, where high solubility is less important, roller dried powder is frequently used. The different physical characteristics of the two types of powder may also govern the choice of powder to be used.

### *Buttermilk powder*

Buttermilk powder made from sweet cream is suitable for human consumption and, because of its similarity to skimmed milk powder, can replace it in many instances. It can be used in bread baking and flour confectionery, in the manufacture of processed cheese, the preparation of sugar confectionery of the caramel and fudge type, and in the manufacture of ice cream. It can also be used for animal feeding.

Buttermilk powder made from sour cream can also be used for animal feeding, provided that it has not developed a rancid, oily flavour.

In the following notes the uses of milk powder and buttermilk powder in various industries are described.

## BAKING AND FLOUR CONFECTIONERY

### *Bread*

The addition of skimmed milk powder to a bread mix, suitably modified, for example, by the inclusion of extra fat, results in a loaf of improved aroma, flavour and keeping quality. The presence of

milk solids tends to give a better grain and texture with a more uniform cellular structure throughout the body of the loaf. Caramelization during baking gives the crust an even, golden-brown colour which is attractive in appearance. The slices toast easily and uniformly.

To obtain these advantages in the finished loaf certain modifications in the bread-making process are necessary, due to the adverse effect of skimmed milk solids on the loaf volume and dough consistency. Slightly more improver is needed, as well as additional fat, to give the required texture, volume and baking qualities. The fermentation time also needs to be increased, because the buffering action of skimmed milk solids tends to reduce the diastatic activity of the dough. The addition of a little sugar helps to overcome the reduction in gas production. Additional water is also required, as skimmed milk solids increase the water absorptive capacity of the dough. A good powder usually requires the addition of up to half its own weight of water.

Preliminary heat treatment of skimmed milk to denature some of the milk proteins is said to overcome some of the above difficulties, but the addition of sugar and fat is still necessary to obtain the best product.

In Australia a special skimmed milk powder containing 0.02 per cent potassium bromate, 4 per cent hydrogenated stearin and 1 per cent glyceryl monostearate is manufactured for use in bread. It gives good results and is an example of a "tailor made" product for a particular purpose.

#### *Flour confectionery*

Skimmed milk powder is of considerable value to the baker, since it is readily available, is economical in use as well as in storage space, and has reasonably uniform properties from batch to batch. It has good keeping qualities and is more convenient to handle than liquid milk. The presence of skimmed milk powder in cakes increases the stability of the batter, thus leading to a product of greater volume and improved grain and texture. The buffering action of skimmed milk powder is also of value when making specialities, such as angel food cakes where the reaction is slightly acid (pH 5.5), or chocolate cakes which require a slightly alkaline reaction (pH 8.5). Skimmed milk powder in cakes and biscuits improves crust colour and eliminates the necessity for heavy baking to obtain a good colour.

#### *Dry cake mixes*

Dry cake mixes are increasingly popular with housewives because they contain all the essential ingredients ready mixed and, in most cases, require the addition only of water or water and egg. Skimmed milk powder is widely used in the preparation of these products and

is an essential ingredient for good volume, texture, appearance, flavour and nutritional value.

Buttermilk powder of good quality derived from fresh cream can be used in place of skimmed milk powder in bread, flour confectionery and dry cake mixes.

#### *Egg albumen substitutes*

An egg albumen substitute for use in confectionery and bakery processes must have the capacity to produce a foam which is stable on the addition of flour or sugar. By certain additions and modifications in the manufacture of skimmed milk powder which affect the milk proteins, it is possible to produce a powder with the required foaming properties which can be used successfully and economically as a substitute for egg albumen. Such products are most useful in the manufacture of meringue type confectionery.

### MARGARINE

In the preparation of margarine the use of skimmed milk powder for carrying mother cultures and bulk cultures has the advantage that the solids content of the reconstituted skimmed milk can be controlled so that a uniform product results.

A solids content of about 11 per cent is claimed to give more active cultures than those produced in a milk of 8.5–9.0 per cent solids-not-fat content. In addition, the suitability of each batch of skimmed milk powder for use in culture preparation can easily be established by checking against the batch in use, thus eliminating variations in culture activity.

Spray is more suitable than roller dried powder for culture preparation because of its greater solubility. The importance of fresh spray dried powder of the highest solubility and lacking in inhibitory properties cannot be over-emphasized for this purpose. It should not have absorbed moisture, be free flowing, with low acidity and low bacterial count. After reconstitution, the skimmed milk should be pasteurized and then cooled to 70–72°F (21–22°C) and inoculated with the desired amount of culture, usually 0.5–1.5 per cent. This inoculated milk is then thoroughly mixed and held at 70–72°F (21–22°C) for about 12–16 hours, until the desired acidity, aroma and flavour have developed. It should then be kept cool (below 40°F or 5°C) until required for use.

### CHOCOLATE AND CONFECTIONERY

Although milk crumb is used extensively in the manufacture of milk chocolate, milk powder is also used. Generally, roller dried full cream powder is preferred as it is not difficult to grind to a smooth product and gives a far less viscous chocolate than spray dried full

cream powder. Considerable quantities of skimmed milk powder, however, are used in the preparation of compound couvertures for biscuits and flour confectionery and for this purpose the spray dried powder, which gives a smoother mix, is preferred. Skimmed milk powder can also be used in sugar confectionery of the caramel and fudge type and, since reconstitution is necessary, the spray dried product is preferable because of its better solubility. Good quality spray dried buttermilk powder can be used in place of skimmed milk powder in the preparation of compound couvertures for biscuits and flour confectionery as well as in sugar confectionery of the caramel and fudge type.

#### MANUFACTURED MEAT PRODUCTS

It is claimed that the addition of skimmed milk powder during the preparation of meat products that are chopped and cooked results in improved colour, flavour, texture and slicing quality and, at the same time, reduces shrinkage, eliminates crumbling, increases yield and reduces fat losses. Both spray and roller dried skimmed milk powders are equally satisfactory for use in sausages and other cooked meat products and the required amount of powder is incorporated in the dry state in the mix during the making of the products. About 5 per cent skimmed milk powder can be added without changing the mixing procedure or cooking time, or losing the meat flavour. If much more is used loss of flavour is likely. Skimmed milk powder should not be substituted for lean meat, but rather as an addition to improve the product.

#### SOUPS

In the preparation of cream soups for canning it is customary to include milk to give the characteristic flavour and appearance. Fresh liquid milk is often used, but there may be some advantages in employing a reconstituted milk prepared from full cream powder which has a more consistent composition. Spray dried full cream powder is preferable because of its greater solubility.

Similarly, in the manufacture of soup powders, the addition of milk powder facilitates the production of a more uniform product, of good flavour and texture; spray dried skimmed powder is preferable because of its greater solubility and better keeping quality. Full cream milk powder used in the soup mix may tend to shorten the shelf life of the product.

#### ICE CREAM

The use of milk products in the manufacture of ice cream is almost universal and with modern developments in manufacturing tech-

niques skimmed milk powder is the most convenient way of incorporating milk-solids-not-fat in the final product.

The ice cream manufacturer requires spray dried skimmed milk powder which has the maximum solubility and a complete absence of off-flavours or taints. It should be purchased in containers which will keep the contents dry and are of such a size that each complete package is used quickly. Scoops and other implements used for handling the milk powder must be kept clean and dry. Experience shows that ice cream pre-packed or dispatched in bulk after having been hardened and stored for upwards of 24 hours should contain about 11 per cent of milk-solids-not-fat, depending on the nature and proportion of the other ingredients. The governing factor in deciding the total amount of milk-solids-not-fat which may be incorporated is the quantity of available water in the mix. This must be related to the lactose portion of the non-fatty milk solids in order to obtain a correctly balanced mix which, when frozen into ice cream and stored, will not develop ice crystals through a deficiency in lactose, or sandiness due to an excess of lactose.

The protein portion of the milk-solids-not-fat has a most important bearing on the whipping quality of the mix during the freezing process. It has been found that a correctly balanced mix, with the appropriate amount of lactose, includes the correct quantity of protein to give the required whipping quality.

In the manufacture of ice cream using fresh milk as the basis, a considerable improvement in the storage life of the product can be obtained by using between 2 and 3 per cent of skimmed milk powder dissolved in the liquid milk in addition to the other ingredients.

Soft ice cream is usually prepared from mixes containing 10-12 per cent milk-solids-not-fat. As it is not normally stored after freezing the ingredients need not be balanced as carefully as in other types. It is thus possible to exceed the content of non-fatty milk solids which would normally be required to balance the mix and, when this is done, the additional protein gives better body to the final ice cream.

Skimmed milk powder is most conveniently used by adding it to the measured weight of water in the mixer-pasteurizer as the first of the solid ingredients when the water has reached a temperature of 80-90°F (27-32°C). It should be added slowly with the agitator running at high speed and, when it has been evenly dispersed, the other solids may be added.

#### CANTEENS AND INSTITUTIONS

Milk powders are much used in canteens and institutions for preparing tea, coffee or cocoa, cakes, custards, puddings and sauces. For

best results, it is essential to use a good quality powder, preferably spray dried because of its greater solubility, and to take great care in reconstitution. Absolute cleanliness is essential and complaints are often attributable to carelessness in handling rather than faults in the original milk powder. When reconstituting, the required amount of powder should be added gradually to part of the water, at a temperature of 112–140°F and stirred in thoroughly, either by hand or mechanical mixer, until reconstitution is complete; the remainder of the water is then added. The product should then be treated as ordinary milk and, if not intended to be used immediately, cooled and kept cool in a refrigerator. Each batch should be used up and the remains of an old batch should not be added to a freshly reconstituted batch.

#### FEEDINGSTUFFS

Skimmed milk powder is a valuable ingredient of many compound feedingstuffs used for animals and poultry, including turkeys. It is particularly valuable for young animals where a high quality diet is essential for rapid growth and healthy development. Amongst its many advantages the following are noteworthy:

- (a) it is a moderately rich source of protein;
- (b) the protein is highly digestible and assimilable by all classes of livestock, especially young animals;
- (c) the protein is of high biological value and includes all the essential amino-acids at levels related to the needs of the growing animal;
- (d) it has a low fat content and is therefore less likely to go rancid and so affect adversely certain other essential components of the diet;
- (e) the carbohydrate component—lactose or milk-sugar—is easily broken down in the digestive tract of young animals before they have fully developed the necessary enzymes capable of dealing with other forms of carbohydrate;
- (f) the ash or mineral matter contains *inter alia* useful levels of calcium and phosphorus in proportions well suited to absorption;
- (g) the powder is a very useful source of certain vitamins of the B complex, in particular riboflavin, which all young animals need in the early stages of development.

The uses of skimmed milk powder in the feeding of various types of livestock are illustrated below.

#### *Calves*

The newly-born calf must have colostrum, but within a few days it can be taken off milk and successfully fed on either a milk-

substitute gruel, of which skimmed milk powder forms a major part, or a highly digestible synthetic dry food containing a proportion of skimmed milk powder. The latter contains practically no fat and is too low in energy value to be a satisfactory food by itself, but this can be remedied by the inclusion of an alternative source of fat or oil. Skimmed milk powder is a most valuable source of the nutrients needed for bone and flesh development. Most commercial gruels used as a substitute for whole milk are based on skimmed milk powder and are usually made up at the rate of 1 lb of the gruel to a gallon of warm water.

### *Pigs*

Economic pig production today is dependent on good weaning weights of pigs at about eight weeks. In consequence, it is now common practice, when the piglets are about two weeks old, to supplement the natural nourishment supplied by the sow with a creep feed, to which the piglets have free access. Up to about 5 per cent of skimmed milk powder is usually included in such a creep feed.

### *Poultry, including turkeys*

Skimmed milk powder is frequently used at a 5 per cent level in baby chick feeds and in the starter rations for turkey poults up to eight weeks. It is also often used at a similar level in the rations of breeding hens and turkeys, owing to the need for riboflavin to ensure good hatchability in eggs.

Buttermilk powder, when available, can often be usefully substituted for skimmed milk powder in animal feedingstuffs.

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